

ANNEX G

Methodology for Estimating CH₄ Emissions from Petroleum Systems

The methodology for estimating methane emissions from petroleum systems is based on the 1999 EPA draft report, *Estimates of Methane Emissions from the U.S. Oil Industry* (EPA 1999). Seventy activities that emit methane from petroleum systems were examined for this report. Most of the activities analyzed involve crude oil production field operations, which accounted for 97 percent of total oil industry emissions. Crude transportation and refining accounted for the remaining emissions at about one and two percent each, respectively.

The following steps were taken to estimate methane emissions from petroleum systems.

Step 1: Calculate a Detailed Emission Estimate for 1995 Based on the 1999 EPA Report

The emission factors used for the 1995 base year estimate of methane emissions came from the 1999 EPA draft report. An industry peer-review process identified improvements to activity data for oil wells and tank venting. These recommendations were incorporated into the estimate provided in this inventory. In addition, the EPA reviewed data on the number of oil well completions each year for two years after the initial estimates to ensure that the most up-to-date reports for 1995 were incorporated. The inventory also incorporates updated 1995 data for the number of offshore oil production platforms and the number of crude oil loadings into marine vessels. The activity factors for all years are updated to include these data. The 1995 base year format is used as a basis for estimating emissions 1990-94 and 1996-99 by including the appropriate updated activity factors for each year.

Step 2: Collect Oil Industry Activity Data

Several approaches were used to develop annual activity data for 1990 through 1994 and 1996 through 1999. Most activity data were updated annually at the same level of detail as the 1995 estimate, using reports from the U.S. Department of Energy (DOE) and the oil industry. For cases in which annual data were not available but the activity factors were known to correlate well with changes in oil production rates, the activity factors were scaled from a base year in proportion to annual oil production rate changes. For a small number of sources, 1999 data were not yet available. In these cases, the 1998 activity factors were used. In the few cases where no data was located, activity data based on oil industry expert judgment were used.

Step 3: Select Emission Factors

The 1995 emission factors were used for all years, 1990 through 1999. Many of the emission factors are based on field tests performed several years ago while others were taken from more recent work. The more recently developed emission factors use tank emission models developed by the American Petroleum Institute for estimating emissions from fixed roof and floating roof tanks.

Step 4: Estimate Emissions for Each Activity

Emissions from each of the 70 petroleum system activities analyzed were estimated by multiplying the activity data for each year by the corresponding emission factor. Table G-1, Table G-2, and Table G-3 provide the 1999 activity factors, emission factors, and emission estimates. Table G-4 provides a summary of emission estimates for the years 1990 through 1999.

Table G-1: 1999 CH₄ Emissions from Petroleum Production Field Operations

Activity/Equipment	Emission Factor Units	Activity Factor Units	Emissions (Bcf/yr)
Vented Emissions:			47.515
Oil Tanks	18 scf of CH ₄ /bbl crude	1,258 MMbbl/yr (non stripper wells)	22.512
Pneumatic Devices, High Bleed	345 scfd CH ₄ /device	138,675 No. of high-bleed devices	17.473
Pneumatic Devices, Low Bleed	35 scfd CH ₄ /device	257,539 No. of low-bleed devices	3.245
Chemical Injection Pumps	248 scfd CH ₄ /pump	28,034 No. of pumps	2.538
Vessel Blowdowns	78 scfy CH ₄ /vessel	184,562 No. of vessels	0.014
Compressor Blowdowns	3,775 scf/yr of CH ₄ /compressor	2,511 No. of compressors	0.009
Compressor Starts	8,443 scf/yr. of CH ₄ /compressor	2,511 No. of compressors	0.021
Stripper wells	2,345 scf/yr of CH ₄ /stripper well	348,867 No. of stripper wells vented	0.818
Well Completion Venting	733 scf/completion	4,087 Oil well completions	0.003
Well Workovers	96 scf CH ₄ /workover	43,013 Oil well workovers	0.004
Pipeline Pigging	2.40 scfd of CH ₄ /pig station	0 No. of crude pig stations	0.000
Offshore Platforms, Gulf of Mexico	1,283 scfd CH ₄ /platform	1,848 No. of oil platforms	0.865
Offshore Platforms, Other U.S. Areas	1,283 scfd CH ₄ /platform	24 No. of oil platforms	0.011
Fugitive Emissions:			2.778
Offshore Platforms, Gulf of Mexico	56 scfd CH ₄ /platform	1,848 No. of oil platforms	0.038
Offshore Platforms, Other U.S. Areas	56 scfd CH ₄ /platform	24 No. of oil platforms	0.000
Oil Wellheads (heavy crude)	0.13 scfd/well	15,837 No. of hvy. crude wells *	0.001
Oil Wellheads (light crude)	16.6 scfd/well	208,800 No. of lt. crude wells *	1.267
Separators (heavy crude)	0.15 scfd CH ₄ /separator	10,840 No. of hvy. crude seps.	0.001
Separators (light crude)	14 scfd CH ₄ /separator	98,699 No. of lt. crude seps.	0.499
Heater/Treaters (light crude)	19 scfd CH ₄ /heater	67,595 No. of heater treaters	0.474
Headers (heavy crude)	0.08 scfd CH ₄ /header	8,318 No. of hvy. crude hdrs.	0.000
Headers (light crude)	11 scfd CH ₄ /header	75,710 No. of lt. crude hdrs.	0.300
Floating Roof Tanks	338,306 scf CH ₄ /floating roof tank/yr.	24 No. of floating roof tanks	0.008
Compressors	100 scfd CH ₄ /compressor	2,797 No. of compressors	0.102
Large Compressors	16,360 scfd CH ₄ /compressor	0 No. of large comps.	0.000
Sales Areas	41 scf CH ₄ /loading	1,788,522 Loadings/year	0.073
Pipelines	0 scfd of CH ₄ /mile of pipeline	30,467 Miles of gathering line	0.000
Well Drilling	0 scfd of CH ₄ /oil well drilled	13,440 No. of oil wells drilled	0.000
Battery Pumps	0.24 scfd of CH ₄ /pump	172,051 No. of battery pumps	0.015

Note: Totals may not sum due to independent rounding.

Table G-1: 1999 CH₄ Emissions from Petroleum Production Field Operations (Continued)

Activity/Equipment	Emission Factor Units	Activity Factor Units	Emissions (Bcf/yr)
Combustion Emissions:			1.765
Gas Engines	0.08 scf CH ₄ /HP-hr	17,634 MMHP-hr	1.411
Heaters	0.52 scf CH ₄ /bbl	2146.6 MBbl/yr	0.001
Well Drilling	2,453 scf CH ₄ /well drilled	5,949 Oil wells drilled, 1995	0.015
Flares	20 scf CH ₄ /per Mcf flared	495,273 Mcf flared/yr	0.010
Offshore Platforms, Gulf of Mexico	481 scfd CH ₄ /platform	1,848 No. of oil platforms	0.324
Offshore Platforms, Other U.S. Areas	481 scfd CH ₄ /platform	24 No. of oil platforms	0.004
Process Upset Emissions:			0.548
Platform Emergency Shutdowns	256,888 scfy/platform	1,872 No. of platforms	0.481
Pressure Relief Valves	35 scf/yr/PR valve	79,303 No. of PR valves	0.006
Well Blowouts Offshore	5.0 MMscf/blowout	2.25 No. of blowouts/yr	0.011
Well Blowouts Onshore	2.5 MMscf/blowout	19.8 No. of blowouts/yr	0.050
Total (excluding stripper wells)			52.61

Note: Totals may not sum due to independent rounding.

Table G-2: 1999 CH₄ Emissions from Petroleum Transportation

Activity/Equipment	Emission Factor Units	Activity Factor Units	Emissions (Bcf/yr)
Vented Emissions:			0.240
Tanks	0.021 scf CH ₄ /yr/bbl of crude delivered to refineries	5,434 MMbbl crude feed/yr	0.112
Truck Loading	0.520 scf CH ₄ /yr/bbl of crude transported by truck	57.8 MMbbl crude feed/yr	0.030
Marine Loading	2.544 scf CH ₄ /1000 gal. crude marine loadings	30,624,321 1,000 gal./yr loaded	0.078
Rail Loading	0.520 scf CH ₄ /yr/bbl of crude transported by rail	8.4 MMbbl. Crude by rail/yr	0.004
Pump Station Maintenance	36.80 scf CH ₄ /station/yr	536 No. of pump stations	0.000
Pipeline Pigging	39 scfd of CH ₄ /pig station	1,072 No. of pig stations	0.015
Fugitive Emissions:			0.050
Pump Stations	25 scfCH ₄ /mile/yr.	53,614 No. of miles of crude p/l	0.001
Pipelines	0 scf CH ₄ /bbl crude transported by pipeline	7,639 MM bbl crude piped	0.000
Floating Roof Tanks	58,965 scf CH ₄ /floating roof tank/yr.	824 No. of floating roof tanks	0.049
Combustion Emissions:			0.000
Pump Engine Drivers	0.24 scf CH ₄ /hp-hr	NA No. of hp-hrs	NA
Heaters	0.521 scf CH ₄ /bbl.burned	NA No. of bbl. Burned	NA
Total			0.290

Note: Totals may not sum due to independent rounding.

Table G-3: 1999 CH₄ Emissions from Petroleum Refining

Activity/Equipment	Emission Factor Units	Activity Factor Units	Emissions (Bcf/yr)
Vented Emissions:			1.224
Tanks	20.6 scfCH ₄ /Mbbbl	1,899 Mbbbl/cd heavy crude feed	0.014
System Blowdowns	137 scfCH ₄ /Mbbbl	14,804 Mbbbl/cd refinery feed	0.739
Asphalt Blowing	2,555 scfCH ₄ /Mbbbl	505 Mbbbl/cd production	0.471
Fugitive Emissions:			0.093
Fuel Gas System	439 McfCH ₄ /refinery/yr	158 Refineries	0.069
Floating Roof Tanks	587 scf CH ₄ /floating roof tank/yr.	767 # of floating roof tanks	0.000
Wastewater Treating	1.88 scfCH ₄ /Mbbbl	14,804 Mbbbl/cd refinery feed	0.010
Cooling Towers	2.36 scfCH ₄ /Mbbbl	14,804 Mbbbl/cd refinery feed	0.013
Combustion Emissions:			0.091
Atmospheric Distillation	3.61 scfCH ₄ /Mbbbl	14,804 Mbbbl/cd refinery feed	0.020
Vacuum Distillation	3.61 scfCH ₄ /Mbbbl	6,874 Mbbbl/cd feed	0.009
Thermal Operations	6.02 scfCH ₄ /Mbbbl	1,941 Mbbbl/cd feed	0.004
Catalytic Cracking	5.17 scfCH ₄ /Mbbbl	5,019 Mbbbl/cd feed	0.009
Catalytic Reforming	7.22 scfCH ₄ /Mbbbl	3,314 Mbbbl/cd feed	0.009
Catalytic Hydrocracking	7.22 scfCH ₄ /Mbbbl	1,376 Mbbbl/cd feed	0.004
Hydrotreating	2.17 scfCH ₄ /Mbbbl	1,557 Mbbbl/cd feed	0.001
Hydrotreating	6.50 scfCH ₄ /Mbbbl	8,283 Mbbbl/cd feed	0.020
Alkylation/Polymerization	12.6 scfCH ₄ /Mbbbl	1,090 Mbbbl/cd feed	0.005
Aromatics/Isomerization	1.80 scfCH ₄ /Mbbbl	933 Mbbbl/cd feed	0.001
Lube Oil Processing	0.00 scfCH ₄ /Mbbbl	191 Mbbbl/cd feed	0.000
Engines	0.006 scfCH ₄ /hp-hr	1,468 MMhp-hr/yr	0.008
Flares	0.189 scfCH ₄ /Mbbbl	14,804 Mbbbl/cd refinery feed	0.001
Total			1.408

Note: Totals may not sum due to independent rounding.

Table G-4: Summary of CH₄ Emissions from Petroleum Systems (Gg)

Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Production Field Operations	1,263	1,276	1,232	1,175	1,144	1,136	1,111	1,109	1,075	1,011
Tank venting	564	570	548	519	502	493	485	484	466	433
Pneumatic device venting	559	564	545	521	506	507	491	490	475	447
Wellhead fugitives	24	26	25	24	25	25	25	24	24	24
Combustion & process upsets	46	46	45	45	45	45	45	46	45	44
Misc. venting & fugitives	70	70	69	67	66	66	65	65	64	63
Crude Oil Transportation	7	6	6	6	6	6	6	6	6	6
Refining	25	24	24	25	25	25	26	27	27	27
Total	1,294	1,307	1,262	1,206	1,175	1,168	1,143	1,142	1,108	1,044

Note: Totals may not sum due to independent rounding.